

EVALUATION OF CELERY POWDER AND CHERRY POWDER AS ALTERNATIVES
TO SODIUM NITRITE AND SODIUM ERYTHORBATE IN RESTRUCTURED BEEF
JERKY

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ABSTRACT

The objective of this study was to determine the impact of clean label ingredients on water activity, residual nitrite, color, sensory analysis, and consumer acceptance in restructured beef jerky. Evaluated treatments included a control (CON) with traditional ingredients, Cherry Powder (CP), VegStable 506 (VS), and a Natural Treatment (NAT) using both Cherry Powder and VegStable 506. Jerky treated with CON had the lowest water activity ($P < 0.05$); the remaining treatments were comparable and met required government limits. Residual nitrite values were comparable across all treatments ($P > 0.05$). All values were within acceptable limits when evaluated for L* values; CON was the darkest across all treatments ($P < 0.05$). Sensory attributes were comparable in all treatments ($P > 0.05$). Sensory and laboratory analysis indicates the use of CP and VS should be considered as viable alternatives for sodium nitrite and sodium erythorbate in restructured beef jerky.

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INTRODUCTION

Curing of meat has been practiced for centuries as a way to preserve meat products. Recently, there has been a growing trend in the demand for natural or clean label products. According to the United States Department of Agriculture (USDA), natural products are required to be free from containing any artificial flavor or flavoring, coloring ingredient, or chemical preservative and must be minimally processed (USDA-FSIS, 2005). Ingredients used in products considered to be clean label must be minimally processed and cannot be chemically altered. These requirements prohibit the use of the following ingredients in products intended to be clean label: sodium nitrate/nitrite and sodium erythorbate. However, these ingredients are very important in the production of processed meats, as they not only give the products flavor, but act as antimicrobial agents to aid in preserving the meat. Substitutes for these conventional ingredients include: celery juice powder, cherry powder, and sea salt. These alternative ingredients were identified by Rourke (2016). Traditionally, the production of jerky utilizes cure ingredients such as: sodium nitrite and sodium erythorbate. Jerky can be produced as a sliced whole muscle product or as a ground and formed product. There has been little research done to determine the impacts of natural ingredients on ground and formed beef jerky. By substituting sodium nitrite with celery juice powder, sodium erythorbate with cherry powder, salt with sea salt, and sugar with Turbinado sugar, a clean label jerky product can be produced. The purpose of this study is to determine if substituting celery juice powder and cherry powder has an impact on quality of a restructured beef jerky product.

LITERATURE REVIEW

Jerky Production

Jerky is a product preserved through a cooking and dehydrating process to be shelf-stable. To be considered shelf-stable, jerky must meet certain regulations. These regulations include specific levels for Moisture: Protein Ratio (MPR) and water activity level. In order to be labeled as jerky, all products must have a MPR of 0.075:1 or less (USDA-FSIS, 2005). Water activity levels are also important in determining if the product is shelf-stable. The Food Safety and Inspection Service (FSIS) recommends water activity levels be below 0.86 for products packaged in aerobic conditions and 0.91 or lower for products packaged in anaerobic conditions (USDA-FSIS, 2014). Products that are packaged at a water activity of 0.91 to 0.86 must be labeled refrigerate after opening. Jerky can be processed from various meat and poultry proteins. FSIS requires that species and kind of jerky be on the label. Jerky can be produced as a sliced whole muscle product or as a restructured product. Restructured products are those that have been ground and formed into a specific shape and size. A restructured jerky can be classified as Jerky Chunked and Formed, Jerky Ground and Formed, or Jerky Sausage. Jerky Ground and Formed is meat product that has been ground and molded and formed into strips (USDA-FSIS, 2005).

Clean Label Demands

The demand for clean label, natural food products has grown steadily over the past decade. The FDA and USDA currently have not established a legal definition for products that fall under the term clean label; nonetheless, sodium nitrite and sodium erythorbate are not considered clean label options as they are not minimally processed. A survey conducted

by Ingredient Communications determined that 73% of consumers were willing to pay premiums for clean label products (Nunes, 2017). Of those surveyed, many were willing to pay premiums of up to 75% for products that had ingredients they recognized. A report by the USDA-ERS (Economic Research Service) shows the steady increase in the market share of organic produced products from 2005-2014 (USDA-ERS, 2017). In 2015, the global share of clean label products was sitting at 165 billion and projected to hit 180 billion of the market share by 2020 (Natural Products Insider, 2016). These reports and trends indicate that the processed meat market would be ready for a new, clean label snack product.

Curing Agents

Nitrites are added to processed meat products to begin the curing process. Sodium nitrite is a restricted ingredient that when added to a meat product produces the cured pink color associated with processed meats. Nitrites are restricted and cannot exceed certain levels. The allowed amount depends on the product being produced. In ground (comminuted) meat products, the maximum level of sodium nitrite allowed is 156 parts per million (PPM) or 0.25 oz for every 100 lbs of meat (USDA-FSIS, 1995). Sodium nitrite is also added to meat products to act as an antimicrobial. Nitrite is a strong inhibitor to anaerobic bacteria, most importantly *Clostridium botulinum*, and also aids in control of other microorganisms such as *Listeria monocytogenes* (Sebranek and Bacus, 2007). Traditional sources of nitrites added to cured meat products are found in cure salt. Because nitrites are a restricted ingredient, cure salt has been dyed a pink color to distinguish it from salt. Cure salt is a combination of table salt (93.75%) and sodium nitrite (6.25%). As sodium nitrite is considered a chemical preservative, it is not approved as a natural ingredient. One study

stated that natural curing requires a natural nitrite source, which can be derived from sea salt, vegetables, vegetable juices, or beet powder (Bacus, 2006). Celery juice powder is a natural alternative to utilizing cure salts in processed meats.

Cure Accelerator

Cure accelerators are added to processed meats to increase the rate in which the cured pink color is developed. Conventional ingredients that have been identified as cure accelerators include the isomers sodium erythorbate and sodium ascorbate. Sodium erythorbate functions by accelerating the conversion of nitrite to nitric oxide. The USDA has set limits on how much sodium erythorbate can be added to processed meats. The maximum level of sodium erythorbate allowed in a processed meat product is 547 PPM (USDA-FSIS, 1995). In addition to aiding in acceleration of the cured color, sodium erythorbate also has antioxidant properties. The antioxidant properties inhibit lipid oxidation in the processed meats. A clean label alternative to sodium erythorbate is cherry powder, which is derived from the acerola cherry (Rourke, 2016). The acerola cherry is a natural source of ascorbic acid; therefore, it functions similar to sodium ascorbate/erythorbate in processed meats. It has been determined that the addition of cherry powder to a product has effects that are similar to sodium erythorbate due to its ascorbic acid content (Terns et al., 2011).

MATERIALS AND METHODS

Jerky Production

Beef Shoulder Clods (IMPS 114C) were purchased from a commercial food distribution company. The product was received by the Angelo State University Food Safety and Product Development Laboratory (FSPD), and was held under refrigeration (4°C) prior to processing. The Infraspinatus was removed, and the remaining product was denuded (removal of fat). Next, 100 lb of lean was course ground through a 12.7 mm grinder plate using a Thompson mixer grinder (Model 840, Thompson Meat Machinery, Queensland AU). The 100 lb meat block was then divided equally into four 25 lb batches. The 25 lb batches were randomly assigned to one of four treatments (Table 1) including: 1) a control containing all conventional ingredients (CON), 2) a treatment substituting both vegetable powder and cherry powder for sodium nitrite and sodium erythorbate, respectively (NAT), 3) a treatment of conventional ingredients with VegStable 506 (vegetable powder) substituted for sodium nitrite (VS), and 4) a treatment of conventional ingredients with cherry powder as a substitute for sodium erythorbate (CP). Each batch was mixed with appropriate seasonings for the assigned treatment and then ground through a 3.97 mm grinder plate using the same Thompson mixer grinder. The product was placed in a vacuum stuffer (Model VF50, Albert Handtmann Maschinenfabrik, Biberach Germany) and extruded onto smokehouse screens using a modified stuffing horn. The jerky was extruded in 110 g increments producing product that was 3.5 cm wide and 0.8 cm thick.

Table 1. Formulation for Restructured Jerky Treatments

Ingredient**	CON ^a	CP ^b	NAT ^c	VS ^d
Salt	0.40	0.40	0.40	0.40
Water	1.00	1.00	1.00	1.00
Black Pepper	0.10	0.10	0.10	0.10
Onion Powder	0.06	0.06	0.06	0.06
Garlic Powder	0.08	0.08	0.08	0.08
Cure Salt ^a	0.06	0.06	0.00	0.00
Sodium Erythorbate	0.012	0.00	0.00	0.012
VegStable 506	0.00	0.00	0.04	0.04
Cherry Powder	0.00	0.004	0.004	0.00

Product was formulated at 25lbs

**Ingredients were formulated in lbs

^a CON = Control

^b CP = Cherry Powder

^c NAT = Natural

^d VS = VegStable 506

Both the mixer grinder and vacuum stuffer were cleaned and sanitized between each treatment to ensure no carryover. The smokehouse screens were loaded on a smokehouse truck and cooked in a smokehouse (Alkar Model 700 HP, Lodi, WI), without the addition of smoke, using identical jerky cycles (Table 2). To achieve a consistently dried product, the humidity was gradually lowered throughout the course of the cycle to prevent the outside surface from drying too quickly. Samples were individually packaged and frozen for later analysis.

Objective Color Score

Following cooking, the jerky was allowed to reach 23 °C and was evaluated for objective color scores. Jerky was evaluated for CIE L* (lightness), a* (redness), and b* (yellowness) color space values with a Minolta Colorimeter (Model CR-410, Minolta Corp., Ramsey, NJ). Prior to recording color scores, the colorimeter was calibrated using a white calibration plate. Calibration values were Y =94.6, x =.3133, and y =.3195. The samples were cut into two equal pieces and placed flush side by side in order to cover the lens of the colorimeter and get accurate results. Measurements were taken using both sides of the jerky strip. Recordings were taken in triplicate and averaged (n = 20/treatment).

Water Activity

Water activity of jerky samples was determined using the same 20 samples/treatment utilized for objective color scores following the recording of color scores. Water activity was determined using an AquaLab water activity meter (Model Series 3, Decagon Devices, Pullman, WA). The target water activity was 0.86.

Table 2. Smokehouse Cycle for Restructured Jerky Treatments

Step	HR	MIN	D.B. ^a (°F)	W.B. ^b (°F)
1	-	-	170	0
2	0	45	170	0
3	1	0	155	147
4	2	0	155	145
5	1	0	155	143
6	2	0	150	140
7	2	0	150	138
8	2	0	150	136
9	2	0	150	120
10	4	0	145	90

- Step 1 is the smokehouse rising to temperature.

^aD.B. = Dry Bulb temperature in °F.

^bW.B. = Wet Bulb temperature in °F.

Prior to testing, the water activity meter was calibrated using AquaLab calibration samples. Calibration samples had a value of 0.750 ± 0.003 . The product was cut into small pieces and placed in two sampling cups per treatment. Sampling of product followed the manufacturer's protocol

Nitrite Analysis

Nitrite levels were determined by analyzing 20 strips per treatment. Previously frozen samples were used for nitrite evaluation. Values were determined by extracting the nitrite ion and mixing it with Greiss reagent (sulfanilamide + N-(1-naphthyl)-ethylenediamine) (NED). Strips from each treatment were cut into 5-gram samples and frozen in liquid nitrogen and blended into a fine powder. Prior to testing, a standard was prepared, and values were recorded using a spectrophotometer (Evolution 201, Thermo Fisher Scientific, Shanghai China). The standard curve was made by adding an ascending concentration of sodium nitrite solution from 0 to 40 mL in descending amounts (45-5 mL) of deionized water. Additionally, 2.5 mL of both sulfanilamide and NED reagent were added to the standard. During testing, the samples were placed into a 50 mL beaker with 40mL of 80°C water and shaken. Samples were then transferred to 500 mL flasks and filled with 80°C water to 300 mL. The samples were then placed in an 80°C water bath for two hours. Following the hot water bath, samples were cooled to approximately 23°C. After cooling to room temperature, 40 mL of samples were filtered into 50 mL flasks using 15.0 cm filter paper 410 (VWR). Following filtering, 2.5 mL of sulfanilamide was added to each flask and allowed to sit for 5 min. Next, 2.5 mL of NED reagent was added and allowed to sit for 15

min for color formation. The values were then read at 540 nm and compared to the pre-recorded standard curve.

Sensory Evaluation

All testing involving human participants was approved by the Angelo State University Institutional Review Board. (#BRA-061118, Appendix A). Sensory analysis was conducted using a panel of 7 – 8 trained panelists. Panelists were trained prior to evaluation by an experienced trainer at the FSPD. Panelists were trained to evaluate attributes using practice samples and adjustments made until the panelist was approved for the trials. Panels were conducted in accordance with AMSA (1995) approved procedures. Both subjective color scores, as well as taste sensory values were evaluated using the same strips. Jerky strips were removed from vacuum packaging and three samples from each treatment were randomly assigned for each panel. Subjective color scores were evaluated under florescent lighting at the FSPD. Each sample was evaluated for the following attributes: Cured Color Intensity (CCI), Cured Color Characterization (CCC), Cured Color Fading (CCF), and Visual Acceptability (VA). Following color evaluation, samples were cut into 12.7 mm increments for taste evaluation and randomly reorganized. Sensory attributes for taste include: Initial (IT) and Sustained Tenderness (ST), Initial (IJ) and Sustained Juiciness (SJ), Flavor Intensity (FI), Off Flavor (OF), and Overall Acceptability (OA). Between samples, panelists were provided apple juice, unsalted crackers, and water to cleanse their palates. Samples were evaluated during 7 panels of 12 samples (n = 84).

Statistical Analysis

All data was initially entered into excel and imported into SAS (SAS Inst. Inc., Cary, NC). Data was analyzed using analysis of variance (ANOVA). Dependent variables include: water activity, color scores, sensory attributes, and nitrite values. Each strip of jerky served as the experimental unit. Differences were evaluated at a predetermined alpha level of 0.05. Mixed procedures of SAS 9.4 was utilized for statistical analysis.

RESULTS AND DISCUSSION

Objective Color

Objective Color values were determined using CIE L*, a*, and b* color space values. Values for L* measure lightness of a product using a scale ranging from 0 (black) to 100 (white). Values for a* measure product redness. These values are recorded as negative values (green) to positive values (red). Color score for b* determine yellowness with negative values signifying blue to positive values signifying yellow. When evaluating L* values, CON samples had a similar color to NAT samples ($P > 0.05$) (Table 3). Treatments of CP and VS were similar to each other, with values of 22.30 and 20.41, respectively, but they were significantly darker than CON jerky samples which had a L* value of 26.65 ($P < 0.05$). Samples taken from CP, VS, and NAT all had similar L* values ($P > 0.05$). Values for a* showed CON and CP were similar to each other ($P > 0.05$), but significantly redder ($P < 0.05$) compared to VS and NAT treatments. Sindelar et al. (2010), reported L* values taken from a whole muscle jerky treated with vegetable juice powder had no significant differences when compared to a control using sodium nitrate. Mewa et al., (2018) showed a whole muscle dried beef product had L* values ranging from 22.40 to 26.20. Samples taken from jerky treated with VS showed redder a* values ($P < 0.05$) than those taken from those in the NAT treatment. Values reported for a* showed a significant interaction between treatments while b* values were similar between treatments (Sindelar et al., 2010). Color score values for b* showed results comparable to a*, with CON and CP having similar ($P > 0.05$) values to each other.

Table 3. Least Square Means (\pm Standard Error) for Minolta L* (lightness), a* (redness), and b* (yellowness) values of Control, Cherry Powder, Natural, and VegStable treated Restructured Jerky n=32

Color Reading	CON ^a	CP ^b	NAT ^c	VS ^d	P-Value
L*	26.65 \pm 1.19 ^x	22.30 \pm 1.19 ^y	23.72 \pm 1.19 ^{xy}	20.41 \pm 1.19 ^y	0.004
a*	38.43 \pm 1.21 ^x	40.98 \pm 1.21 ^x	21.62 \pm 1.21 ^z	25.92 \pm 1.21 ^y	<0.0001
b*	8.42 \pm 0.52 ^x	9.24 \pm 0.52 ^x	3.62 \pm 0.52 ^y	3.18 \pm 0.52 ^y	<0.0001

^{xyz} Values within a color reading with a different superscript differ ($P < 0.05$).

^aCON = Control

^bCP = Cherry Powder

^cVS =VegStable 506

^dNAT = Natural

The values taken from CON and CP were significantly more yellow ($P < 0.05$) than VS and NAT. Jerky samples taken from VS and NAT showed similar values ($P > 0.05$).

Subjective Color

Sensory data for subjective color, was collected during trained sensory panels. Data for subjective color was gathered from 7-8 panelists and then averaged. Panelists evaluated color under florescent lighting for Cured Color Characterization (CCC), Cured Color Fading (CCF), Cured Color Intensity (CCI), and Visual Acceptability (VA). Least square means for subjective color attributes CCC, CCF, and CCI are presented in Table 4. Cured Color Characterization was measured on a scale from 1 indicating very dark red cured color to 8 indicating light pinkish cured color. Data collected for Cured Color Characterization showed similar values in samples taken from CON and NAT with values of 1.31 and 1.54 respectively. The CON (1.31) samples were significantly darker ($P < 0.05$) compared to samples taken from CP (1.65) and VS (1.67). However, data collected showed that Cured Color Characterization was similar across CP, NAT, and VS with values of 1.65, 1.54, and 1.67, respectively. When evaluating CCF panelists used a scale from 1, indicating no fading to 5, indicating extreme fading. All treatments had similar subjective color values ($P > 0.05$) ranging from 1.02 – 1.06 when evaluating Cured Color Fading, indicating little to no fading (Table 4). Cured Color Intensity was scaled from 1, indicating very intense cured color to 7, indicating no cured color.

Table 4. Least Square Means (\pm Standard Error) for Subjective Color of Control, Cherry Powder, Natural, and VegStable treated Restructured Jerky n=84

Attribute	CON ¹	CP ²	NAT ³	VS ⁴	<i>P</i> -Value
CCC ^a	1.31 \pm 0.09 ^y	1.65 \pm 0.09 ^z	1.54 \pm 0.09 ^{yz}	1.67 \pm 0.09 ^z	0.02
CCF ^b	1.04 \pm 0.017	1.02 \pm 0.017	1.06 \pm 0.017	1.05 \pm 0.017	0.28
CCI ^c	4.74 \pm 0.17 ^y	3.71 \pm 0.17 ^z	4.12 \pm 0.17 ^z	4.15 \pm 0.17 ^z	0.0003

^{yz} Values within an attribute with a different superscript differ ($P < 0.05$)

¹CON = Control

²CP = Cherry Powder

³NAT = Natural

⁴VS =VegStable 506

^a Cured Color Characterization 1= dark red cured color, 8= light pinkish cured color

^b Cured Color Fading 1= no fading, 5= extreme fading

^c Cured Color Intensity 1= very intense cured color, 7= no cured color

When evaluating data collected for Cured Color Intensity, results showed that CON (4.74) was significantly higher ($P < 0.05$) when compared to the CP, NAT, and VS (3.71, 4.12, and 4.15, respectively). Data collected from CP, NAT, and VS showed similar values ($P > 0.05$) across all three treatments. Panelists found that CON presented a dark red color which corresponds with the higher a^* values recorded using the colorimeter. Values collected for Visual Acceptability are recorded in Table 5. Visual Acceptability was determined by the panelist's willingness to purchase the product. Data taken from CON showed the lowest level of acceptance with evaluators visually accepting only 52.90% of samples. CP exhibited the highest acceptability with 73.72% of samples classified as acceptable. Data collected from NAT and VS showed visual acceptability of 66.23% and 61.94%, of samples respectively. Color is the major deciding factor in consumer preference (AMSA, 2012). The results for Visual Acceptability are based primarily on color.

Table 5. Percentage of Acceptability for Subjective Color of Control, Cherry Powder, Natural, and VegStable treated Restructured Jerky n=84

Acceptability	CON ^a	CP ^b	NAT ^c	VS ^d
No ¹	47.1	26.28	33.77	38.06
Yes ¹	52.90	73.72	66.23	61.94

¹Yes/No –Do you consider this product acceptable?

^aCON = Control

^bCP = Cherry Powder

^cNAT = Natural

^dVS =VegStable 506

Water Activity

Water activity (A_w) was measured using an AquaLab water activity meter on a scale from 0.00 – 1.00. When evaluating water activity of jerky, values must be below 0.91 if the product is to be stored at room temperatures in anaerobic conditions. Additionally, if the water activity of the product is below 0.86 the product can be stored in aerobic conditions (USDA-FSIS, 2014). Products with a water activity ranging from >0.85 to < 0.91 are considered shelf stable; however, they must be labeled ‘Refrigerate after Opening’ or ‘Keep Refrigerated’ due to the exposure to oxygen (9 C.F.R. § 317.2 k, 2007). The lower (closer to 0) the water activity the drier the final product. When evaluating A_w values for jerky, the CON treatment was significantly drier at 0.88 ($P < 0.05$) than CP, NAT, or VS (0.89, 0.90, 0.90, respectively) treatments (Table 6). Trained panelists were unable determine a difference in dryness. Sindelar et al. (2010) reported no significant differences in A_w between a control treatment and a no nitrite added treatment. Ranges for Sindelar’s study ranged from 0.82 to 0.86. Sindelar utilized whole muscle product in his study which could have resulted in different A_w values compared to the restructured product used in this project. Jerky samples taken from treatments CP, NAT, VS were all similar in A_w values ($P > 0.05$).

Nitrite

Nitrite values for a comminuted product cannot exceed 156 ppm (USDA-FSIS, 1995). All recovered nitrite values were below 156 ppm. When evaluating nitrite values all treatments showed similar values ($P > 0.05$) (Table 6). Nitrite values ranged from 27.67ppm to 35.34ppm. All values recorded for nitrite were below the maximum of 156 ppm limit.

Table 6. Least Square Means (\pm Standard Error) for water activity and nitrite values of Control, Cherry Powder, Natural, and VegStable treated Restructured Jerky

Trait	CON ^a	CP ^b	NAT ^c	VS ^d	<i>P</i> -Value
A _w (n=32)	0.88 \pm 0.003 ^y	0.89 \pm 0.003 ^z	0.90 \pm 0.003 ^z	0.90 \pm 0.003 ^z	0.0002
Nitrite ¹ (n=80)	32.85 \pm 2.28	35.34 \pm 2.28	27.67 \pm 2.28	31.90 \pm 2.28	0.13

^{yz}Values with a different superscript differ ($P < 0.05$)

^aCON = Control

^bCP = Cherry Powder

^cNAT = Natural

^dVS = =VegStable 506

¹Nitrite values recorded in ppm

When comparing a sodium nitrite control to a vegetable powder treated product no significant differences were found between treatments (Sindelar et al. 2010). Results recorded for this study were similar to those recorded by Sindelar.

Palatability Analysis

After collecting data for subjective color, the samples were then randomized and used for collecting sensory data for taste. The same panel of 7-8 panelists was used for both subjective color and taste. Taste attributes that were evaluated included: Initial (IT) and Sustained Tenderness (ST), Initial (IJ) and Sustained Juiciness (IJ), Flavor Intensity (FI), Off Flavor (OF), and Overall Acceptability (OA). Attributes IT and ST were scaled: 1=extremely tough to 8=extremely tender. Initial and Sustained Juiciness were scaled: 1=extremely dry to 8= extremely juicy. Flavor intensity was measured: 1=not intense to 8= extremely intense. Off Flavor was scaled: 1=extreme off flavor to 4=no off flavor. Overall Acceptability was scaled: 1=dislike extremely to 8=like extremely. Data collected for sensory attributes for taste are presented in Table 7. All treatments had similar values for IT ($P > 0.05$) ranging from 3.01 to 3.31. Data collected for ST showed no difference ($P > 0.05$) across treatments; reported values were CON (3.80), CP (4.12), NAT (3.85), and VS (3.91). Initial Juiciness with values ranging from 2.78 to 2.87 showed similar results ($P > 0.05$) across all treatments. No statistical difference ($P > 0.05$) was found for SJ in all treatments. Trained panelists were unable to determine differences in juiciness between treatments, which contradicts findings with A_w levels.

Table 7. Least Square Means (\pm Standard Error) for Sensory Analysis of Control, Cherry Powder, Natural, and VegStable treated Restructured Jerky n=84

Attribute	CON ^a	CP ^b	NAT ^c	VS ^d	<i>P</i> -Value
Initial Tenderness ¹	3.01±0.11	3.31±0.11	3.04±0.11	3.07±0.11	0.19
Sustained Tenderness ¹	3.80±0.12	4.12±0.12	3.85±0.12	3.91±0.12	0.23
Initial Juiciness ¹	2.82±0.09	2.85±0.090	2.87±0.09	2.78±0.09	0.90
Sustained Juiciness ¹	3.34±0.1	3.42±0.1	3.47±0.1	3.37±0.1	0.79
Flavor Intensity ¹	5.83±0.07	5.75±0.07	5.76±0.07	5.83±0.07	0.70
Off Flavor ²	3.99±0.02	3.96±0.02	3.95±0.02	3.95±0.02	0.28
Overall Acceptability ¹	5.48±0.1	5.58±0.1	5.41±0.1	5.58±0.1	0.52

^aCON = Control.

^bCP = Cherry Powder.

^cNAT = Natural.

^dVS = VegStable 506

¹1 = extremely tough, extremely dry, not intense, and dislike extremely; 8 = extremely tender, extremely juicy, extremely intense, like extremely.

²1= extreme off flavor; 4 = none

Differences in the results from the trained panels and A_w tests can likely be correlated to the water activity meter being able to evaluate minute differences that are beyond the trained panelists' ability to determine. Values reported for SJ were CON (3.34), CP (3.42), NAT (3.47), and VS (3.37). There was no difference ($P > 0.05$) in data collected for Flavor Intensity across all treatments. Values for FI ranged from 5.75 to 5.83. All treatments had similar values for OF ($P > 0.05$) with values ranging from 3.95 to 3.99. No statistical difference was found in OA ($P > 0.05$). Values reported for OA ranged from 5.41 to 5.58.

CONCLUSION

The purpose of this study was to examine the impact of VegStable 506 and Cherry Powder as alternatives for sodium nitrite and sodium erythorbate on quality attributes and consumer acceptance of clean label jerky. Objective color differences were detected. However, subjective color determined that all treatments had acceptable color, with the test treatments having a higher acceptance. The CP treatment had the highest visual acceptability. When evaluating water activity, all treatments were below 0.91, indicating they were acceptable to be labeled “Refrigerate after Opening.” The CON treatment had the lowest water activity, indicating that it was the driest of the tested treatments. Trained panelists were unable to detect and difference in dryness. Residual Nitrite values were below maximum acceptable PPM levels of 156 ppm, with CP having the highest value. Palatability analysis determined that there was no difference across all treatments. Research determined that VegStable 506 and Cherry Powder maintain quality attributes and increase consumer acceptance of restructured beef jerky.

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APPENDIX A



ANGELO STATE UNIVERSITY

College of Graduate Studies

Institutional Review Board

6/11/2018

Dr. Loree Branham
Dept. of Agriculture
Angelo State University
San Angelo, TX 76909

Dear Loree:

The proposed project submitted by your student Bryce Patton titled, "*Evaluation of Celery Powder and Cherry Powder as Alternatives to Sodium Nitrite and Sodium Erythorbate in Restructured Beef Jerky*" has been approved in accordance with federal regulations 45 CFR 46.

The approval is effective beginning June 11, 2018. Please be aware that the protocol will expire one year from its original approval date. If the study will continue beyond that date, you must submit a request for continuation before the current protocol expires.

The approved addendum is for protocol #BRA-061118. Please include this number in the subject line of in all future communications with the IRB regarding the protocol.

Sincerely,

A handwritten signature in black ink, appearing to read 'Teresa Hack', with a stylized flourish at the end.

Teresa (Tay) Hack, Ph.D.
Chair, Institutional Review Board

Dr. Teresa Hack, IRB Chair | ASU Station #11025 | San Angelo, Texas 76909

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